

## Book reviews

### **How Coal Properties Influence Emissions**

Robert M. Davidson, International Energy Agency, CCC/28, 56 pp., 2000

### **Opportunities for Coal Preparation to Lower Emissions**

Gordon R. Couch, International Energy Agency, CCC/30, 46 pp., 2000

This pair of International Energy Agency books gives the reader an opportunity to review recent literature on the fundamental coal properties important in emissions from coal-fired power plants. The next step in the process, control of emissions at the power plant, was discussed previously by Couch (1995). Considering the rapid changes in emissions regulations and in the industry response to the regulations, perhaps IEA will be updating the latter title in the future.

Davidson's *How Coal Properties Influence Emissions* is an update of Skorupska (1993). Davidson reviews sulfur in a brief chapter, the brevity perhaps reflecting the relative maturity of sulfur dioxide-control technologies. Somewhat indicative of the entire book, the single, unrefereed reference on maceral properties is, arguably, not the best choice (at least not as the sole reference). IEA books, overall, rely on a variety of literature sources, some from the major refereed journals, but also many from conference proceedings, agency reports, and previous IEA publications. The result can be an apprehension that some results reported are not yet fully verified.

Nearly half the text is devoted to  $\text{NO}_x$  emissions, an important component of emissions control, but one that the author admits cannot be predicted from fuel properties alone. Rather, the station type and the mode of operation can greatly outweigh the importance of fuel nitrogen.

The coverage of ash properties, while brief, provides a good summary of the impact of minerals and major oxides on pollution control devices, specifically electrostatic precipitators (ESP). The electrical resistivity of the ash, ash chemistry, ash quantity,

and the particle size and distribution influences ESP performance. As an example, resistivity is fundamental in fly ash capture. If the resistivity is too low, ash particles will lose charge before collection and be re-entrained in the flue gas. If the resistivity is too high, particles are not easily charged, requiring a larger ESP. Sulfur can be oxidized to  $\text{SO}_3$ , which forms  $\text{H}_2\text{SO}_4$  in the presence of moisture.  $\text{H}_2\text{SO}_4$  condenses on the fly ash as an electrically conductive film, easing the precipitation of fly ash. A consequence of the switch to low sulfur coals is change in ESP performance, low-S coals producing fly ash that is more difficult to collect.

A review of trace elements closes the discussions of coal properties. Trace element emissions, with particular attention being paid to mercury, continue to be an important topic of discussion. Besides the fundamental concerns about Hg, other elements may have an impact on the performance of pollution-control devices, particularly catalytic equipment designed to reduce levels of  $\text{NO}_x$  in the flue gas.

At several places in *Opportunities for Coal Preparation to Lower Emissions*, Couch, in the role of a devil's advocate, questions the need for coal preparation, for example:

... for the purpose of reducing emissions, there is little point in coal preparation to reduce macro elements, since virtually all solids are captured [by emissions control systems] (p. 28).

While this argument could be advanced for countries with well-developed emissions-control systems, much of the development of coal-fired power plants will be in China and India, both of which have the

potential for major improvements in delivered coal quality. Couch counters his argument in the final chapter, outlining the benefits of coal preparation:

- consistency of quality of the coal product,
- improved boiler availability and operability,
- reduced transport costs.

As an example of the benefits of a consistent coal product, use of high-ash coal leads to:

- increased capacity of coal handling systems with an increased potential for erosion of components in the system;
- increased boiler size;
- lower boiler efficiency due to increased potential for slagging, fouling, and erosion;
- increased solids loading in the ESP;
- decreased volatile content and heating value of the feed coal; and,
- increase in coal hardness (depending on the nature of the mineral matter).

Loss of boiler availability due to decreased heating value or due to outages caused by poor quality coal costs the electric utility, the primary customer of coal, large amounts of money. The added cost is incurred not only in repair and maintenance costs, but also in the cost of buying kilowatts from other utilities, a very large expense at times of power shortages, and in the lost opportunity to sell power to other utilities. Thus, if nothing else, the role of coal preparation is the production and delivery of a (relatively) consistent fuel, as contracted by the customer.

As noted, the coal industries in China and India, accounting for over one-third of the world coal production, and the coal industries in other countries with lesser production, have tremendous room for improvement in delivered coal quality. Reduction of SO<sub>2</sub> emissions is an obvious example. In portions of southwestern China, arsenic is associated with pyrite, therefore reduction of sulfur would also serve to greatly reduce the levels of a potentially hazardous air pollutant. In developed countries, having power plants with high thermal efficiencies, a 1000-MWe plant emits 1000 t CO<sub>2</sub>/h. CO<sub>2</sub> emissions are higher in India and China where the thermal efficiencies are about 29% compared to about 38% in the US. Im-

provement of the quality of coal feed to Chinese power plants sufficient to improve the efficiency to 33% would result in a 20% reduction in CO<sub>2</sub> emissions.

Among the trace elements in coal, including the “Hazardous Air Pollutants,” Hg and Se are the most difficult to capture. Based on an average Hg content of 0.09 ppm for US coals, Couch estimates Hg emissions from a 500-MWe coal-fired plant to be 0.3 kg/day. Ultimately, Hg emissions may require control, and physical coal cleaning to reduce Hg-bearing minerals, primarily pyrite, is an option for pre-combustion Hg control. Post-combustion options include converting flue gas Hg to a solid phase, adsorption of Hg on activated carbon, and removal of Hg in wet scrubbing.

The need for mine planning, and the role of the coal geologist in predicting long-term coal quality, is displayed in two examples where better understanding of coal characteristics at mine-mouth power plants could have prevented coal-related boiler problems. In the first example, a lack of understanding of the extent of a high-Na area at the Loy Yang mine (Victoria) led to unplanned outages due to boiler fouling. In the second example, underestimated faulting in the Selby coal field (England) led to a lower product quality and the need for a preparation plant.

The need for physical coal cleaning has never been greater. Developing countries would benefit from the construction of a coal-cleaning infrastructure to parallel the growing coal-combustion infrastructure. The power industry in developed countries is under continued pressure to lower emissions. Physical coal cleaning is the first step in reducing sulfur and trace elements and helping to ensure a uniform coal feed, a major contributor in maintaining boiler efficiency and reducing CO<sub>2</sub> emissions. Overall, the balance between physical coal cleaning vs. post-combustion emission controls becomes a matter of which party is going to be responsible for the handling of the waste material. It is generally less expensive to handle a relatively coarse, pre-combustion solid waste than to deal with fine solids, both dry and wet, and gaseous emissions following combustion. Somewhat offsetting the disadvantages of dealing with post-combustion products is the possibility of selling bottom ash, fly ash, and flue-gas desulfurization gypsum. For the latter coal-combus-

tion by-product, a high demand for gypsum by the wall-board industry has led to the construction of wall-board plants next to power plants.

Both books are valuable additions to institutional or company libraries. While, in some respects, not as comprehensive as some major publications cited, such as Leonard's (1991) edition of *Coal Preparation* or the series of papers in the journals *Coal Preparation* (1998, vol. 19, no. 3–4) and *International Journal of Coal Geology* (1999, vol. 40, no. 2–3), together the books provide a view of the issues facing coal geologists, mining engineers, and combustion engineers in the year 2000 and for the next few years. Emissions regulations are moving targets, and the concerned parties will always be in the position of reacting to new directives unless they can take the initiative and arm themselves with the knowledge of how to use their coal product in the most environmentally friendly manner possible.

Each book is typical of IEA books in price: £255 in non-IEA member countries, £85 for purchasers in IEA member countries (Australia, Austria, Canada,

Denmark, Finland, Italy, Japan, the Netherlands, Poland, Spain, Sweden, UK, and the USA), and £42.50 for educational establishments within member countries.

## References

- Couch, G.R., 1995. Power From Coal — Where To Remove Impurities? IEA Coal Research, London, IEACR/82, 87 pp.
- Leonard, J.W., 1991. Coal Preparation. Society for Mining, Metallurgy and Exploration, 1131 pp.
- Skorupska, N.M., 1993. Coal Specifications — Impact On Power Station Performance. IEA Coal Research, London, IEACR/52, 120 pp.

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